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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 604

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER March 16, 1918

INCENSE CEDAR

By

J. ALFRED MITCHELL, Forest Examiner

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FOREST SERVICE.

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COMMERCIAL IMPORTANCE.[1]

Incense cedar (*Libocedrus decurrens* Torrey) is comparatively little known on the general market. Only the better grades of lumber are shipped, and not much of this material is produced, owing to the prevalence of "peckiness" or "dry-rot," and to the scattered occurrence of the tree. Frequently it is mixed with other species, there being too small a quantity of it produced in most operations to be handled separately. The local market for it is extensive, however, and it is cut by practically every operator in the mountains of California and southern Oregon, along with the more valuable timber trees with which it grows.

An inquiry among the operators and dealers throughout California in 1912 showed that the total cut for that year, including local consumption, was, in round numbers, 32,810,000 board feet. Table 1 gives the cut in California from 1899 to 1916, exclusive of local consumption, and the value of the cut at prevailing wholesale prices where available.

[1] Acknowledgment is made of the valuable assistance rendered in the gathering of data for this publication by various Forest officers of Districts 5 and 6, whose hearty cooperation has made its preparation possible, and of the assistance of Dr. E. P. Meinecke and Messrs. T. D. Woodbury, C. A. Kupfer, Ralph Hopping, and L. T. Larsen in the compilation of the data and the revision of the manuscript.

TABLE 1.—*Annual production of incense cedar, as reported, and its value at prevailing market prices.*[1]

Year.	Total cut of incense cedar reported.	Average mill-run price.	Total value.
1899[2]	4,882,000	.....	.....
1900	4,049,000	.....	.....
1901	3,550,000	.....	.....
1902	2,424,000	.....	.....
1903	5,478,000	.....	.....
1904	3,157,000	.....	.....
1905	3,043,000	.....	.....
1906	2,876,000	.....	.....
1907	7,018,000	.....	.....
1908[3]	12,790,000	$10.52	$134,551
1909	14,834,000	12.95	192,100
1910	20,846,000	12.80	266,829
1911	16,993,000	11.39	193,550
1912	18,507,000	.....	.....
1913	22,056,000	.....	.....
1914	17,872,000	.....	.....
1915	12,185,000	12.08	147,195
1916	16,587,000	13.05	215,416

[1] Incense cedar forms less than 1 per cent of the total of all timber cut in California.
[2] Data for the years 1899–1907, inclusive, furnished by the California State Development Board.
[3] Data for 1908–1916, inclusive, from reports of the United States Bureau of the Census and the Forest Service.

PRODUCTS AND USES.

Incense cedar is chiefly valuable for its lasting qualities, its durability in contact with soil, and its peculiarities of grain and texture. Its durability was early discovered by settlers and prospectors, as is shown by its extensive use for rails, fence posts, and foundation timbers. Telephone and telegraph companies, railroads, and lumbermen also have recognized its good qualities and utilize it to a considerable extent for poles, stubs, flume timbers, ties, and the like, wherever it is available. Recent developments have shown its adaptability to certain special uses, and a growing demand has sprung up that promises to make this an important Pacific coast species in spite of its characteristic unsoundness and past unpopularity. Table 2 indicates the extent to which incense cedar is used by manufacturers and Table 3 how the total cut of 1912 was divided among various uses.

TABLE 2.—*Consumption of incense cedar by the wood-using industries.*

Industry.	Quantity used annually.		Cost f. o. b. factory.	
			Average per 1,000 feet.	Total.
	Feet b. m.	*Per cent.*		
Pencil slats	3,050,000	52.5	$18.00	$54,900
Doors and sash	2,570,000	44.2	17.75	45,620
Chests and boxes	93,750	1.6	25.00	2,344
Flooring and moldings	62,500	1.1	25.00	1,563
Raisin trays	31,250	.6	16.50	516
Total	5,807,500	100.0	18.07	104,943

NOTE.—See Bulletin No. 3, California State Board of Forestry, "Wood-using Industries of California," by Andrew K. Armstrong, engineer in timber tests, U. S. Forest Service, 1912.

TABLE 3.—*Consumption of incense cedar in 1912, classified by products.*

Use.	Quantity used.		Market price or value.		Total value.
			Range.	Average.	
	Feet b. m.	*Per cent.*			
Lumber	22,500,000	68.6	$10 to $75 per 1,000 feet	$15 per 1,000 feet[1]	$337,500
Ties	3,500,000	10.6	20 cents each	20 cents each	20,000
Pencil slats	3,050,000	9.2	$14.50 per 1,000 feet[2]	$14.50 per 1,000 feet[2]	44,225
Posts	2,500,000	7.6	10 to 35 cents each	18 cents each	35,226
Poles and stubs	500,000	1.5	Stubs, 30 cents Poles, $1.25 to $4.50	30 cents $1.50	3,900
Cordwood	500,000	1.5	$4.50 to $6.50 per cord	$5.50 per cord	5,500
Shingles	250,000	.7	$2.50 to $5 per 1,000 feet	$3.75 per 1,000 feet	7,500
Shakes	10,000	.3	$7 per 1,000 feet	$7 per 1,000 feet	210
Total	32,810,000	100.0			454,061

[1] Mill run No. 2 common or better.
[2] 2⅝-inch rough, f. o. b. cars at main-line points.

LUMBER.

Incense cedar when sound makes excellent lumber, for it is light, soft, and easily worked. It is not, however, a good lumber-producing tree, because of its short body, rapid taper, and susceptibility to "dry-rot" or "peckiness." So common is this that it is a common practice in cruising incense cedar to deduct from 30 to 50 per cent for cull on account of it. Only the occasional sound trees and portions of logs free from dry-rot are sawed into boards, the rest, unless too badly honeycombed, being cut into dimension stuff or ties.

The yield of various grades of lumber from an incense cedar tree depends very largely, of course, on the amount of "dry-rot." This varies so widely, however, in different trees in one locality as well as in trees in different localities that data based on the yields of "pecky" trees would have very little general application. The yields indicated in Table 4 are based therefore on sound trees and are fairly typical of the yield where there is no "dry-rot."

TABLE 4.—*Yield by grade of incense-cedar lumber.*

Grade.	Tree No. 1.		Tree No. 2.	
	Yield in board feet.	Per cent.	Yield in board feet.	Per cent.
Clear	500	17	1,360	17
No. 1 common	900	31	2,340	29
No. 2 common	700	24	1,890	24
No. 3 common	500	17	1,350	17
Cull	300	11	810	13
Total	2,900	100	7,750	100

The price of rough incense cedar lumber, mill run, averages $15 per thousand feet board measure at the mill. The prices paid for it in its manufactured form at centers of distribution and consump-

tion, however, vary widely with its quality and the use for which it is desired. As high as $75 per thousand feet board measure has been paid for select uppers, to be used as pattern stock and in cabinet work; but it is often difficult to dispose of the lower grades at $8 or $10 per thousand, prices which scarcely pay the cost of logging and manufacture. Table 5 shows the range of prices as they were quoted in 1912, and the average prices for the different grades.

TABLE 5.—*Selling price of incense cedar, by grades, f. o. b. mill in 1912.*

Grade.	Range.	Average.
Clears	$30 to $75 per 1,000 feet	$45 per 1,000 feet b. m.
No. 1 common	$22 to $32 per 1,000 feet	$27.50 per 1,000 feet b. m.
No. 2 common[1]	$18 to $22 per 1,000 feet	$20 per 1,000 feet b. m.
Mill run	$10 to $20 per 1,000 feet	$15 per 1,000 feet b. m.

[1] Grades lower than No. 2 common are usually unmerchantable.

The greater portion of the cedar that finds its way into the general market is used by builders for outside trim and interior finish. Its durability, easy working qualities, pleasing grain, rich color, and ability to take a good polish make it particularly desirable for these purposes. Sash and door manufacturers use it to some extent because of its availability and cheapness, although in the aggregate it amounts to but 2 per cent of the total quantity of lumber consumed by this industry. It is used also in the manufacture of chests and wardrobes, the aromatic odor of the wood supposedly rendering them moth-proof. A small quantity is consumed annually for pattern stock, moldings, and raisin trays. Locally, incense cedar is used for dimension stuff and rough construction work, or for sills, culverts, sidewalks, bridge planks, etc., where cheapness or durability are important and the presence of dry-rot does not affect its usefulness.

Cedar is used occasionally in the manufacture of crates and fruit boxes, but owing to its tendency to split in nailing it is considered undesirable. An attempt also has been made to utilize it in the manufacture of cigar boxes, but it was found that the oils contained in the wood imparted a disagreeable flavor to the cigars.

TIES.

In the early nineties there was a considerable demand for incense-cedar ties, and large numbers were hewn in Eldorado, Placer, and Nevada Counties. These ties brought 25 cents each and found a ready market at San Joaquin Valley points, where railroad construction was then under way. As the size and weight of rolling stock increased, cedar was found to be too soft to stand the wear and tear, and its use was abandoned, except for logging roads and spurs where

this was not excessive. To-day, however, with the universal use of tie plates, cedar ties are again coming into more general use in regions where they are available.

PENCIL SLATS.

Although the use of incense cedar for pencil slats is of recent development it bids fair to become more and more important as the supply of southern red cedar becomes exhausted. As is shown in Table 2, the demand of pencil manufacturers for incense cedar has already surpassed that of all other industries.

The qualities of incense cedar which adapt it particularly to this use are its softness, its straight grain, and the ease with which it can be whittled. While its color is not all that could be desired, it stains readily and is highly satisfactory for the cheaper grades of pencils. Dry-rot does not affect its usefulness for this purpose except by increasing the necessary cull, for the sound wood between the cavities caused by the rot can be utilized to a great extent. Some trouble has been experienced with uneven shrinkage in kiln drying after staining, particularly when the wood showed rapid growth. This, however, is a minor difficulty, as cedar is characteristically a slow-growing tree.

Cedar for pencils ordinarily is contracted for by the pencil manufacturers at so much per 1,000 feet board measure, delivered aboard the cars at main-line points. In such cases it usually is bought direct from timber operators. Occasionally, however, stumpage is purchased and the logging contracted for. Pencil wood was formerly shipped in the log, the logs first being peeled; but recently this practice has largely been discontinued, the logs now being sawed into planks of the desired thickness locally and shipped to slat factories as rough lumber. This allows closer culling and reduces freight charges. At the slat mills, usually located at some central shipping point, the cedar is first seasoned and then cut into slats of the desired size; these slats are later sorted, stained if necessary, bundled, and shipped to factories in the East or in Europe for manufacture into pencils.

Cedar suitable for pencil stock brings from $10 to $12.50 per thousand feet board measure in the log and $14.50 per thousand when sawn into planks f. o. b. cars at main-line points, which, while low for lumber in general, is an average price for cedar, when the amount of cull is considered.

POSTS, RAILS, POLES, AND STUBS.

The durability of incense cedar in contact with the soil, its lightness, and the ease with which it splits make it particularly desirable

as a post timber. Few species are prized more highly for this purpose. Since the days of the earliest settlers it has been the chief source of fence posts and rails throughout the mountains and foothills of California.

Posts and rails for the most part are split, the trees first being felled and bucked into the desired lengths. Although in a few cases cedar has been sawed into 4 by 4s or 4 by 5s for this purpose, split posts generally are considered more satisfactory. In good timber two men working together can split out 200 or more posts a day, thus making good wages at from 5 to 6 cents a post, the usual price paid for this work.

In making posts usually the heartwood only is utilized, the sapwood not being durable. Post makers prefer dead and charred cedar logs and snags where the sapwood has rotted and been burned away, leaving thoroughly seasoned heartwood. Such material is usually sound, for if dry-rot had been present in any considerable quantity the entire log would have burned.

It is estimated that at least 230,000 incense cedar fence posts are used annually. Accurate figures, however, are not obtainable, since their use is for the most part local and they are cut in small lots, often by the men who use them. On the National Forests cedar posts form an important item of the free-use business, most of the local ranchers obtaining their supply in this way. In some regions it is an annual custom for those located in the foothills to go into the mountains for a week or two each fall for the purpose of cutting and hauling their year's supply of posts and rails.

The stumpage value of post material varies from 2 to 6 cents per post, according to its accessibility and abundance, dead cedar usually bringing about 1 cent less than green, although it is the more desirable of the two. Throughout the Sierras the price ranges from 2 to 4 cents, except on the Nevada slope, where it is somewhat higher because of its scarcity. The prices at which posts are sold, ranging from 10 to 35 cents, are given in Table 3. This variation, however, is due largely to differences in the cost of transportation to the various market points rather than to differences in the cost of stumpage or manufacture. In the local markets, which consume most of the supply, from 16 to 18 cents is the usual price.

Table 6, based on somewhat limited data, indicates roughly the yield in posts for trees of various diameters. There is, however, such a great variation in the relative width of the sap, the ease of working, and the waste due to rot and knots, that at best a table of this character is only approximate.

TABLE 6.—*Post volume table for incense cedar; basis, 8 trees.*

Diameter, breast-high.	Number of posts.	Diameter, breast-high.	Number of posts.
Inches.		*Inches.*	
24	48	48	120
30	66	54	138
36	84	60	156
42	102		

Large numbers of poles and stubs also are made annually for local use. Like rails and fence posts, these are practically all split, although in a few instances sawed incense cedar poles have been used by power companies in their local lines. Such poles were quoted locally in 1911 at the prices given in Table 7.

TABLE 7.—*Local market prices of sawed incense cedar poles (1911).*

Dimensions.			Market price (each).
Butt.	Top.	Length.	
Inches.	*Inches.*	*Feet.*	
8 by 8	6 by 6	18	$2.35
8 by 8	6 by 6	20	2.50
9 by 9	6 by 6	25	3.50
10 by 10	7 by 7	30	4.50

Owing to the presence of dry-rot and the greater difficulties of transportation, incense cedar poles are not so desirable as poles of the western red cedar of the Northwest, and no attempt therefore has been made to put them on the general market. Split poles approximately 6 inches by 6 inches by 18 feet are frequently used in local telephone-line construction, and bring for this purpose from $1.25 to $1.50 each. The use of such poles, however, is not extensive, owing to the scarcity of timber from which they can be split. Round poles made from incense cedar saplings have also been used to a limited extent. They are not particularly satisfactory, however, owing to their rapid taper and to the preponderance of sapwood.

The extensive use of cedar stubs throughout California has arisen from the necessity of either replacing or stubbing poles which have rotted off at the ground. Stubbing, being the cheaper, has been the practice usually followed, a stout post being set alongside and the old pole wired or bolted to it. As cedar is handy and the most durable timber available, it is usually used for this purpose throughout its range. Though not quoted in the general market, cedar stubs sell locally for 30 cents in regions where the species is fairly abundant.

SHAKES AND SHINGLES.

Incense cedar shakes were used in considerable quantities in the early days by settlers and prospectors, but have been displaced by sugar pine, and to-day the use of cedar for this purpose is limited to an occasional tree cut by some miner or "sky" rancher.

The use of incense cedar for shingles is of considerable importance locally where the general market is not readily accessible. It makes an excellent shingle, but the small amount of sound timber available has prevented its being exploited as a shingle material. Throughout its range the small sawmills supplying the local market frequently cut shingles in limited quantities for home consumption. For this purpose cedar is usually sold in bolts by the cord, the stumpage price being about $1 per cord or $2 per thousand feet board measure. In the local market incense cedar shingles bring from $2.50 to $5 per thousand according to quality, averaging from $3.50 to $3.75. In one instance reported the prices quoted, per 1,000, were as follows:

No. 1 clear heart cedar	$5.00
No. 2 heart and sap	3.75
No. 3 sound knots	2.50

MISCELLANEOUS USES.

Among the various uses of incense cedar not mentioned above, its use as fuel is probably the most important, although the quantity consumed in this way is insignificant when compared with the total amount of fuel wood used annually. It burns readily, gives off considerable heat and but little smoke, and is frequently used where it is plentiful, being generally considered more desirable than pine. Its fuel value, according to Sargent, is 54 per cent that of white oak. In a number of logging operations it is used exclusively for cooking and heating around the camps. In 1911 and 1912 more than 1,800 cords of this species were cut in the vicinity of the Shasta National Forest and disposed of locally for $4 and $4.50 a cord. Ordinarily, however, little is sold; it is cut and used mostly by local inhabitants.

In the raisin country at the upper end of the San Joaquin Valley incense cedar is used extensively for grape stakes. These are split out in much the same manner as posts and are hauled down from the mountains in small quantities and disposed of to the vineyardists in the valley, who utilize thousands of such stakes annually. It is in this region, too, that incense cedar is used for raisin trays, its lightness, durability, and freedom from warping and checking making it particularly desirable.

Experiments have been conducted by the Forest Service at its Forest Products Laboratory, Madison, Wis., to determine the possi-

bilities of incense cedar as a pulpwood. These experiments[1] show that a fairly good grade of paper can be made from it, although somewhat dark in color and difficult to bleach. The available supply, however, in comparison with the more desirable pulpwood species, is too limited to admit of its ever assuming commercial importance for this purpose.

Among the miscellaneous uses for incense cedar is the use of the bark as a top dressing for dirt roads subject to heavy traffic. This is common in the vicinity of logging operations, where heavy hauling is necessary. The tough, stringy bark serves admirably to keep down the dust and reduce the wear and tear on the road. It also serves excellently as a binder where the ground is soft and springy. The bark, which somewhat resembles that of redwood, has also been used in the manufacture of souvenirs and novelties, although not on a commercial scale. Attempts have also been made to utilize it in the manufacture of matches, but it was found to be too brittle.

AVAILABLE SUPPLY.

COMMERCIAL RANGE AND OCCURRENCE.

The commercial range of incense cedar is confined to the west slope of the Sierra Nevadas and the mountains of northern California and southern Oregon, although the tree occurs throughout the mountains of the Pacific coast from central Oregon to northern Mexico. It is found only in mixture with other species, chiefly yellow pine, sugar pine, Douglas fir, and white fir, averaging in general about 8 per cent of the stand. Throughout most of its range a cut of 2,000 feet per acre is a fair average, but in localities particularly favorable to its growth it frequently runs from 4,000 to 7,000 feet to the acre and forms as much as 18 per cent of the merchantable timber. Cuts of from 13,000 to 20,000 feet to the acre have been reported on limited areas where it formed from 30 to 50 per cent of the total stand, but they are unusual. These variations in the proportion of incense cedar in the stand, as well as the stand per acre, are characteristic throughout its entire range, but in the southern Sierras, where the conditions for its growth are most favorable, the average stands are generally heavier and the maximum occurs more frequently. This is brought out by a comparison of the average proportion of incense cedar in the stand and the average stands per acre in different regions. For example, in northern California the average stand per acre is only about 500 feet, 4 or 5 per cent of the total stand; but in the southern Sierras it averages from 18 to 25 per cent and runs from 2,500 to 7,000 feet per acre.

[1] For the results of these tests see "Paper Pulp from Various Forest Woods," Forest Products Laboratory Series, U. S. Department of Agriculture, Forest Service. Issued Mar. 7, 1912.

ESTIMATED STAND.

In round numbers, the available supply of incense cedar in California is estimated at 10 billion feet board measure, and in Oregon and Nevada combined perhaps 1 billion more, or 11 billion feet in all. Of this, approximately one-half is privately owned, the rest being distributed among the various National Forests, parks, etc. Table 8 gives the estimated stand on the various National Forests in California and Nevada.

TABLE 8.—*Incense cedar on National Forests.*

National Forest.	Estimated stand.	Per cent of total.	National Forest.	Estimated stand.	Per cent of total.
	Feet, b. m.			*Feet, b. m.*	
Stanislaus	747,232,000	14.5	Eldorado	200,000,000	3.8
Sierra	731,177,000	14.2	California	198,666,000	3.8
Klamath	729,710,000	14.2	Cleveland	50,000,000	1.0
Sequoia	580,608,000	11.9	Angeles	47,587,000	.9
Plumas	500,000,000	9.7	Modoc	29,850,000	.6
Trinity	416,578,000	8.1	Santa Barbara	7,000,000	.1
Shasta	375,918,000	7.3	Mono	550,000	.....
Tahoe	300,000,000	5.8			
Lassen	215,000,000	4.1	Total	5,129,876,000	100

STUMPAGE VALUE.

The stumpage value of incense cedar on private lands, where it is sold with other species for lumber, varies from $2.50 per thousand, for pencil wood and select post material, to 25 cents per thousand. The average price per 1,000 feet board measure received in sales of incense cedar on the National Forests during the past 11 years are as follows:

1905	$0.25	1909	$1.25	1913	$0.60
1906	.45	1910	1.30	1914	.95
1907	.64	1911	1.50	1915	.80
1908	.88	1912	.92		

The value of the remaining stand, based on the prevailing stumpage price for incense cedar on National Forests in 1915, amounts to approximately $8,500,000 or $9,000,000. For special uses it is worth at least three times that amount to-day and is bound to become still more valuable in the future as the supply diminishes.

THE WOOD.

The wood of incense cedar bears closest resemblance both in gross and minute structure to the bald cypress and western red cedar. It is not likely, however, that incense cedar will be substituted for these woods, so that the question of identity will seldom be raised.

GROSS CHARACTERISTICS.

The wood of incense cedar is soft and light, averaging about 25 pounds per cubic foot in an air-dry condition. Its shipping weight is about 4,500 pounds per thousand feet board measure in the log, and from 2,300 to 2,500 pounds per thousand feet as lumber, depending upon the degree of seasoning. The wood, though not strong, is compact, and has a fine straight grain, splits readily and evenly, and does not check or warp much in seasoning. It works well, takes a good polish, is extremely durable, and is consequently useful in many ways. As the name implies, incense cedar is markedly aromatic, possessing a pronounced resinous and not unpleasant odor.

The sapwood and heartwood are usually well defined, especially in old trees and seasoned lumber. The sapwood is white or cream colored, and the heartwood a light brown, often tinged with red and turning darker with age and exposure to light and air.

The annual rings of growth, though sharply defined in structure, can not always be readily distinguished by the naked eye in slow-growing or suppressed trees and in the outer portion of old, overmature timber, where the rings are narrow. In thrifty growing trees, however, the annual rings put on in early life are often wide and fairly conspicuous.

STRENGTH AND SHRINKAGE.[1]

Incense cedar is not strong when compared with longleaf pine and Douglas fir, owing to the prevalence of defects and its low elastic limit. Figures on its actual strength value for construction purposes are not available, but Table 9 contains the results of tests on small pieces cut from 9 trees growing at an elevation of 3,600 feet, near Weed, Cal. All portions of the tree, both sap and heart, were represented, and the results given are averages of all tests made. The results of similar tests on longleaf pine, Douglas fir, and the more important associated species of incense cedar are given for comparison. Though much weaker than longleaf pine or Douglas fir, incense cedar compares favorably with many other species.

[1] The data on incense cedar are the results of tests conducted at the Forest Service Laboratory operated in cooperation with the University of Washington, Seattle, by O. P. M. Goss, engineer in forest products, July, 1912.

TABLE 9.—*Results of strength tests on incense cedar and associated species as compared with longleaf pine.*

Species.[1]	Specific gravity (based on volume when green).	Bending.				Maximum crushing strength (parallel to grain).	
		Modulus of rupture.		Modulus of elasticity.			
		Pounds per square inch.	Per cent.	Thousands of pounds per square inch.	Per cent.	Pounds per square inch.	Per cent.
Longleaf pine[2] (*Pinus palustris*)	0.528	9,070	100.0	1,540	100.0	4,400	100.0
Douglas fir (*Pseudotsuga taxifolia*)	.418	8,280	91.4	1,597	103.7	4,030	91.7
Incense cedar (*Libocedrus decurrens*)	.363	6,040	66.6	754	48.9	3,030	68.9
White fir (*Abies concolor*)	.350	5,970	65.8	1,131	73.4	2,800	63.6
Sugar pine (*Pinus lambertiana*)	.360	5,270	58.1	966	62.7	2,600	59.1
Western yellow pine (*Pinus ponderosa*)	.377	5,180	57.1	1,111	72.1	2,400	55.0

[1] Tests made on green specimens 2 by 2 inches and free from all defects.
[2] The data on longleaf pine and Douglas fir are from Forest Service Bulletin No. 108; the data on cedar, white fir, sugar pine, and western yellow pine, from Forest Service Circular No. 213.

Tests on strength in relation to moisture, also made on small pieces, showed that thoroughly dry sapwood and heartwood are each 2.50 times as strong as green wood. In these tests the sapwood proved to be slightly stronger than the heartwood at all stages of seasoning. It was not always possible, however, to take the heart and sap specimens from immediately adjacent sections of the tree, which might explain this slight difference.

The average shrinkage in cross section in the above tests, in passing from the green to the thoroughly dry condition, was 9 per cent for the sapwood and 6 per cent for the heartwood.

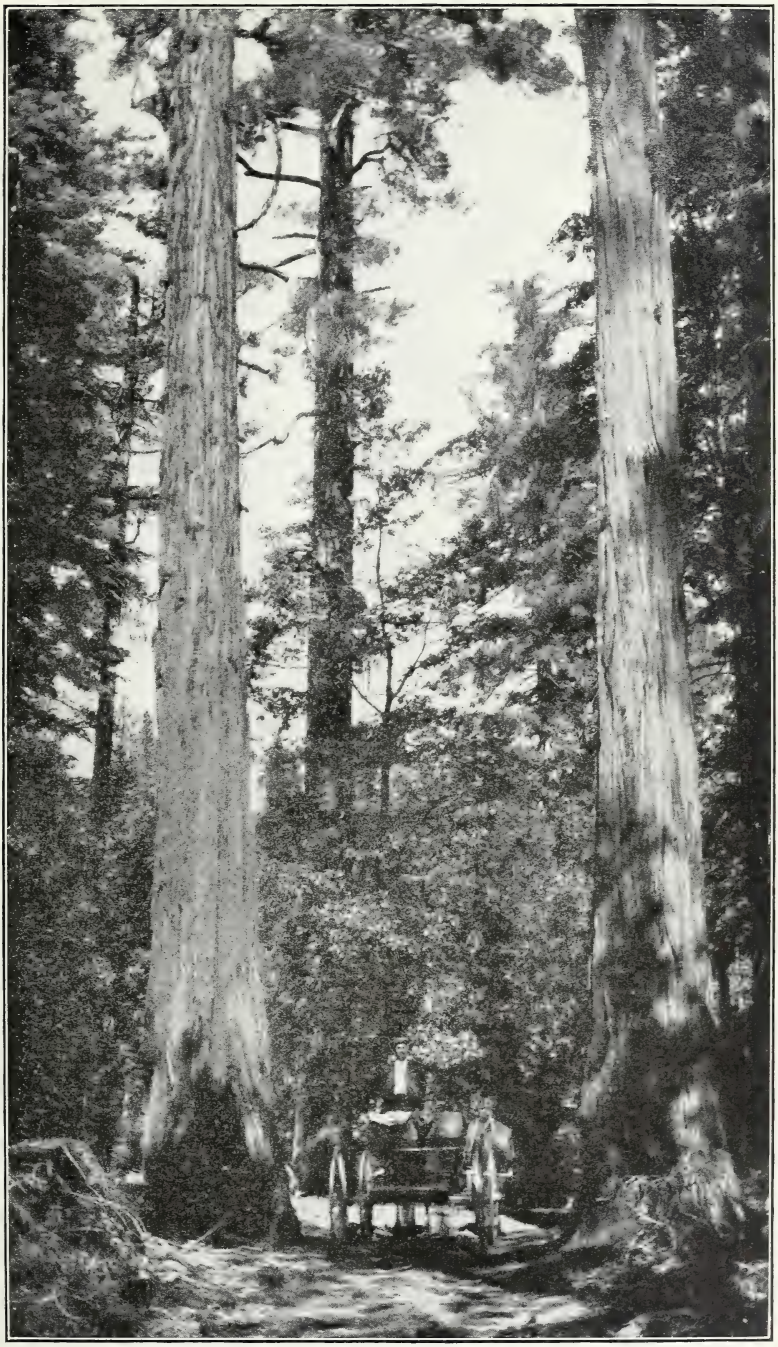
DURABILITY.

Incense cedar is known to be one of the most durable timbers on the Pacific slope. The life of a split heart-cedar fence post is reputed to be from 20 to 30 years, and of rails from 30 to 40, and numerous instances have been cited where they have lasted longer. Sap-cedar posts, on the other hand, are said to last but 5 or 6 years.

THE TREE.

GENERAL DESCRIPTION.

Incense cedar is one of the most characteristic trees of the California forests, its shreddy, deeply furrowed, yellowish-brown or cinnamon colored bark, rapidly tapering bole, and dark-green foliage distinguishing it at once. It resembles somewhat eastern arborvitæ (the white cedar of the north woods) in its flat sprays of scalelike leaves.



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TYPICAL INCENSE CEDARS, SIERRA NATIONAL FOREST.

F–14071A F–3JAM F–7002A F–4JAM

FOUR STAGES IN THE LIFE OF AN INCENSE CEDAR.

1, Youth; 2, middle age; 3, maturity; 4, old age.

This impression is further strengthened by the appearance of the bark on the younger trees, which is flaky rather than shreddy, and by the crown, which is characteristically conical and compact in early life. The pendulous, blunt-pointed cones,[1] however, are unlike those of any other genus, and serve as a ready means of indentification.

As stated, the tree in early life has a compact, sharply conical crown reaching nearly to the ground. The stem is single and erect, tapering more or less sharply to a slender, gracefully flexible tip. The bark on seedlings is usually smooth and dark green or brown, but in the sapling and pole stage it becomes flaky, more or less tinged with red, and shows a lighter yellowish underbark where it has scaled off. In middle life the tree loses somewhat its conical form of crown, although usually retaining it at the top throughout the period of height growth, unless damaged or badly suppressed. The bark, too, at this stage becomes shreddy and takes on the characteristic yellowish-brown color peculiar to this species, or in some localities a decidedly reddish tinge, which it retains throughout its life. At maturity the tree loses most of its symmetry of form, becomes buttressed, swell-butted, and flat-topped. At this period, too, the crown is usually more or less open and irregular, consisting of a few large scraggly limbs, often deformed by mistletoe and witches' brooms—a condition typical of incense cedar in virgin stands.

SIZE.

Incense cedar varies greatly in size. At maturity, under ordinary conditions, it may be said to average from 75 to 110 feet in height and from 30 to 40 inches in diameter breasthigh. Much larger trees, however, frequently occur. The largest of which there is any record is located near Morgan Springs, Tehama County, Cal., and measures 96 inches in diameter at breastheight, 120 feet in height, and contains approximately 9,700 board feet. Trees 150 feet in height occur in several localities throughout the Sierras, and in Tuolumne County a tree 186 feet high was cut recently. Under less favorable conditions for growth, average diameters and heights, particularly heights, are appreciably less. Thus, in the coast ranges and in southern California cedars from 60 to 80 feet high are the rule, though in the Sierras trees from 100 to 125 are not unusual. At high elevations and on poor sites generally the trees are smaller and scrubbier. On good sites at moderate elevations they make their best growth. Table 10 gives, for several localities, the average merchantable length of trees by diameters, the average number of logs, the maximum and minimum heights, and the average top diameters to which the trees can be cut.

[1] Described fully on p. 17.

TABLE 10.—*Relative diameter, heights, and merchantable lengths of incense cedar; basis, 1,089*[1] *trees.*

[CURVED.]

Diameter at breast-height (outside bark).	Relative total height in different localities.			Minimum height.	Maximum height.	Average.				
	Stanislaus National Forest.	Plumas National Forest.	Sequoia National Forest.			Total height.	Merchantable length.	Number of 16-foot logs.	Average top diameter inside bark.	Basis number of trees.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		*Inches.*	
8	22	29	.....	14	41	24	.....	.....	.....	.....
10	30	39	.....	19	54	33	8	0.5	6	.....
12	38	48	.....	23	64	41	14	.5	6	.....
14	45	56	.....	28	74	49	23	1.0	7	.....
16	52	64	.....	32	84	54	29	1.5	8	.....
18	58	70	.....	35	93	62	34	2.0	9	11
20	65	76	.....	40	101	69	40	2.0	9	20
22	71	82	.....	44	108	75	45	2.5	9	37
24	77	86	68	48	114	81	50	3.0	9	43
26	83	90	73	51	122	86	55	3.0	9	44
28	88	93	78	55	128	91	60	3.5	9	67
30	94	95	82	58	133	95	64	4.0	10	87
32	100	97	86	61	138	99	70	4.0	10	96
34	105	98	90	65	143	103	74	4.5	10	84
36	110	100	93	68	147	107	78	4.5	10	104
38	114	101	96	71	151	111	82	5.0	10	102
40	117	102	99	74	154	114	86	5.0	10	63
42	120	104	101	76	158	117	90	5.5	10	67
44	123	106	104	79	162	120	93	5.5	10	76
46	124	108	105	82	165	123	96	6.0	10	58
48	126	110	107	85	168	125	98	6.0	10	34
50	127	112	109	87	171	127	101	6.0	10	33
52	129	.....	110	90	174	129	104	6.5	10	21
54	130	.....	.....	92	176	131	106	6.5	10	8
56	131	.....	.....	94	177	133	109	6.5	10	12
58	132	.....	.....	97	179	134	111	6.5	11	8
60	133	.....	.....	100	180	136	114	7.0	11	9
62	.....	.....	.....	102	181	137	116	7.0	11	2
64	.....	.....	.....	104	182	139	118	7.0	11	2
66	190	285	29	107	183	141	120	7.5	11	1

[1] The difference between this figure and the total number of measurements given as a basis in the different localities is due to the inclusion of additional measurements from other localities in deriving the mean.

LONGEVITY.

Like most of the related species, incense cedar is a long-lived tree. A few records of very large trees have been obtained, and trees from 300 to 500 years old are not unusual. The oldest observed was 542 years old at the stump and measured approximately 51.2 inches in diameter at breastheight. It is probable, therefore, that where it is undisturbed it reaches an age of from 800 to 1,000 years.

FORM.

Incense cedar is characteristically short-bodied and rapid-tapering, a feature which is accentuated as the tree approaches maturity by a tendency to become buttressed and swell butted. This characteristic is further exaggerated by the extreme thickness of the bark on the lower portion of the bole, from 6 to 8 inches being not uncommon in old trees. The relative form of the bole at different ages is shown

in figure 1 and its peculiar habit of buttressing is illustrated in figure 2.

In computing age and volume from stump measurements it is necessary, because of the extreme butt taper of the species, to reduce stump measurements to the relative diameters at some fixed point for the sake of comparison. Table 11, prepared for this purpose, gives in terms of inches and tenths of inches the taper from various stump heights to diameter breasthigh, or 4½ feet above the ground, the standard point of measurement.

TABLE 11.—*Taper in diameter outside of bark from stump height to breasthcight; basis, 101 trees (Plumas National Forest, 1912).*

[CURVED.]

Stump height.	Diameter at breastheight.								
	18	20	22	24	28	32	36	40	48
	Taper.								
Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1.0	4.0	4.4	5.0	5.7	6.7	7.4	8.1	8.7	9.9
1.2	3.7	4.1	4.6	5.2	6.0	6.6	7.2	7.7	8.6
1.4	3.4	3.8	4.2	4.7	5.3	5.9	6.3	6.8	7.5
1.6	3.2	3.5	3.9	4.2	4.8	5.2	5.6	6.0	6.6
1.8	2.9	3.2	3.5	3.8	4.3	4.7	5.0	5.3	5.8
2.0	2.7	2.9	3.2	3.4	3.8	4.2	4.4	4.7	5.1
2.2	2.4	2.7	2.9	3.1	3.4	3.8	4.0	4.3	4.6
2.4	2.2	2.4	2.6	2.8	3.1	3.4	3.6	3.8	4.1
2.6	2.0	2.1	2.3	2.5	2.7	3.0	3.2	3.4	3.7
2.8	1.7	1.9	2.0	2.2	2.4	2.6	2.8	3.0	3.3
3.0	1.5	1.6	1.8	1.9	2.1	2.3	2.5	2.6	2.9
3.2	1.2	1.4	1.5	1.6	1.8	2.0	2.1	2.3	2.5
3.4	1.0	1.1	1.2	1.3	1.5	1.7	1.8	1.9	2.1
3.6	.8	.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7
3.8	.6	.6	.7	.8	1.0	1.1	1.2	1.2	1.3
4.0	.4	.4	.5	.6	.7	.8	.8	.9	.9
4.2	.2	.2	.3	.3	.4	.5	.5	.5	.5

ROOT SYSTEM.

Incense cedar is decidedly windfirm, and few cases of uprooted trees are to be found. In general, the root system is fairly wide spreading and composed of a number of large, stocky, many-branched laterals with numerous short, small, descending offshoots, forming a compact, intricately tangled mass immediately around the base of the tree. The tree does not develop a taproot beyond the early stages, although a pronounced taproot is characteristic of the seedlings, as in most conifers. Incense cedar stands root pruning better than most species and develops numerous laterals, which makes it an easy tree to handle in the nursery.

FOLIAGE AND BRANCHING.

The foliage of incense cedar is evergreen and consists of small, pointed, scalelike leaves, which adhere closely to the slender branch-

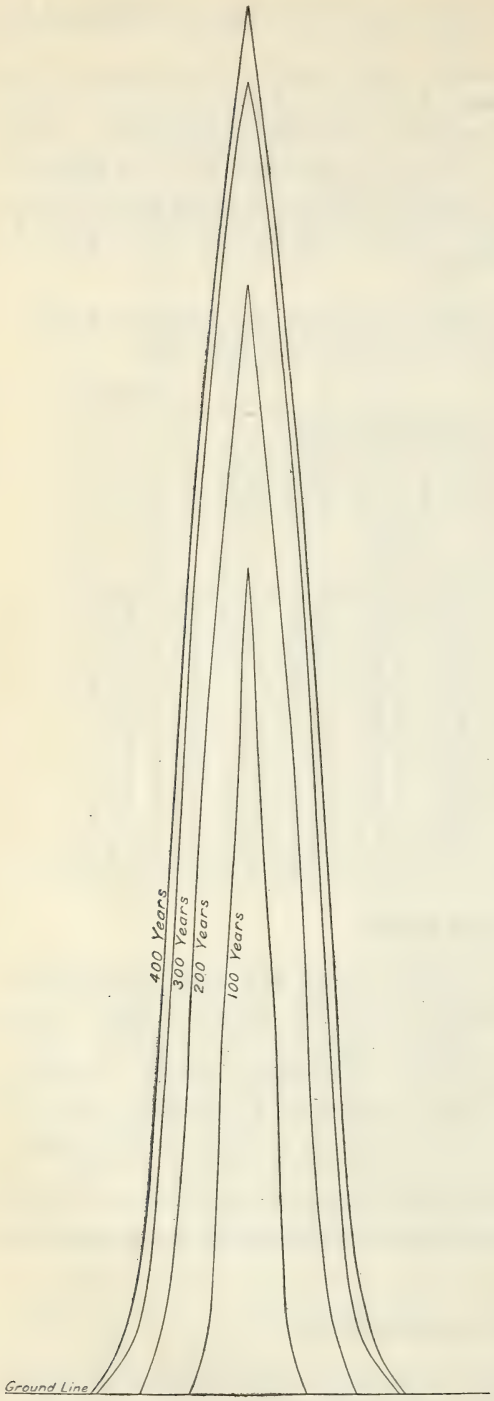

FIG. 1.—Relative form of the bole of incense cedar at various ages.

lets and remain on the tree from 3 to 5 years. The leaves are opposite and four-ranked like those of other species, which are related but are characterized by their long bases, which extend from one-eighth to one-half inch along the branch. They are also keeled, and each is provided with a small resin gland, which accounts for the pungent aromatic odor so noticeable when the leaf is bruised. The younger branchlets have the appearance of being jointed, as two pairs of leaves occur together, at right angles to each other, and overlap slightly the four leaves above.

In the seedling stage incense cedar is characterized by three kinds of leaves (Pl. III), which serve to distinguish it at once from its common associates. The first to appear are the two seed leaves, which measure from 1 to $1\frac{1}{4}$ inches long by one-eighth inch broad. These are followed shortly by one or more branches bearing awl-shaped transitional leaves, which grade off eventually into the normal scalelike foliage. On thrifty, fast-growing seedlings normal leaves are produced the first year. On slower-growing seedlings they do not appear

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FOUR STAGES IN THE DEVELOPMENT OF AN INCENSE CEDAR SEEDLING, SHOWING THE THREE KINDS OF LEAVES—SEED LEAVES, INTERMEDIATE LEAVES, AND TRUE LEAVES.

until the second season. With the appearance of the true leaves the fanlike arrangement of the sprays is first apparent, the seedlings usually developing in one plane for several years.

The branchlets occur alternately, and in one plane, forming an open fan-shaped spray, the smaller side branches of which are often shed about the second year, as is the case with arborvitæ and related species.

The main branches on younger trees are slender and taper gradually, the lower limbs slightly drooping but with upturned tips. Higher up they are more erect, especially as they approach the top. In old age the limbs become thick and angular, tapering rapidly and turning up sharply at the ends, assuming a more or less candelabralike formation. This is particularly true of trees grown on poor sites.

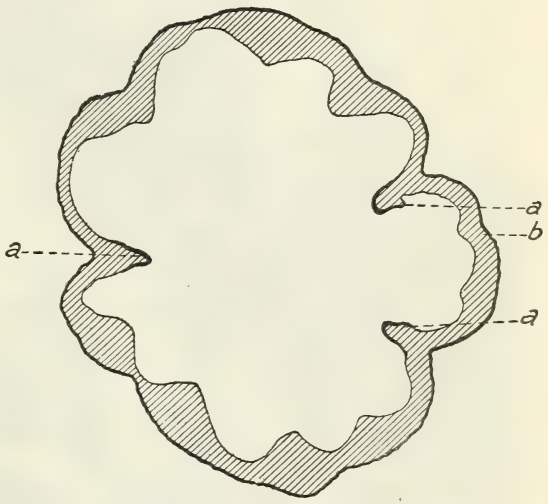


FIG. 2.—Cross section of a mature incense cedar (taken 42 inches above the ground). *a*, old fire scars; *b*, bark.

FLOWERS, FRUIT, AND SEED.

Incense cedar has male and female flowers, which are borne singly at the tips of the twigs of the previous season, usually on separate trees, but occasionally on the same tree and even the same branch. The male or pollen-bearing flowers appear in January as small oblong conelike bodies about one-fourth inch long, and are conspicuous for their golden-yellow color, which often tinges the whole tree during the winter and early spring. The cones or female flowers, at first dark green in color, are usually not noticable until somewhat later. In the summer and fall, however, they turn a yellowish brown and in good seed years are conspicuous by their abundance. Trees standing in the open, even though small, are particularly noticable in this respect, the entire crown frequently being covered with cones. In the fall the cones turn to a russet brown, maturing about September. By October they open and the seeds are distributed, the cones remaining on the trees until the following spring or summer.

The cones are pendulous and from three-fourths inch to 1½ inches long by from one-fourth to five-sixteenths inch in diameter at the thickest part. They are subglobose in form, tapering to a rather

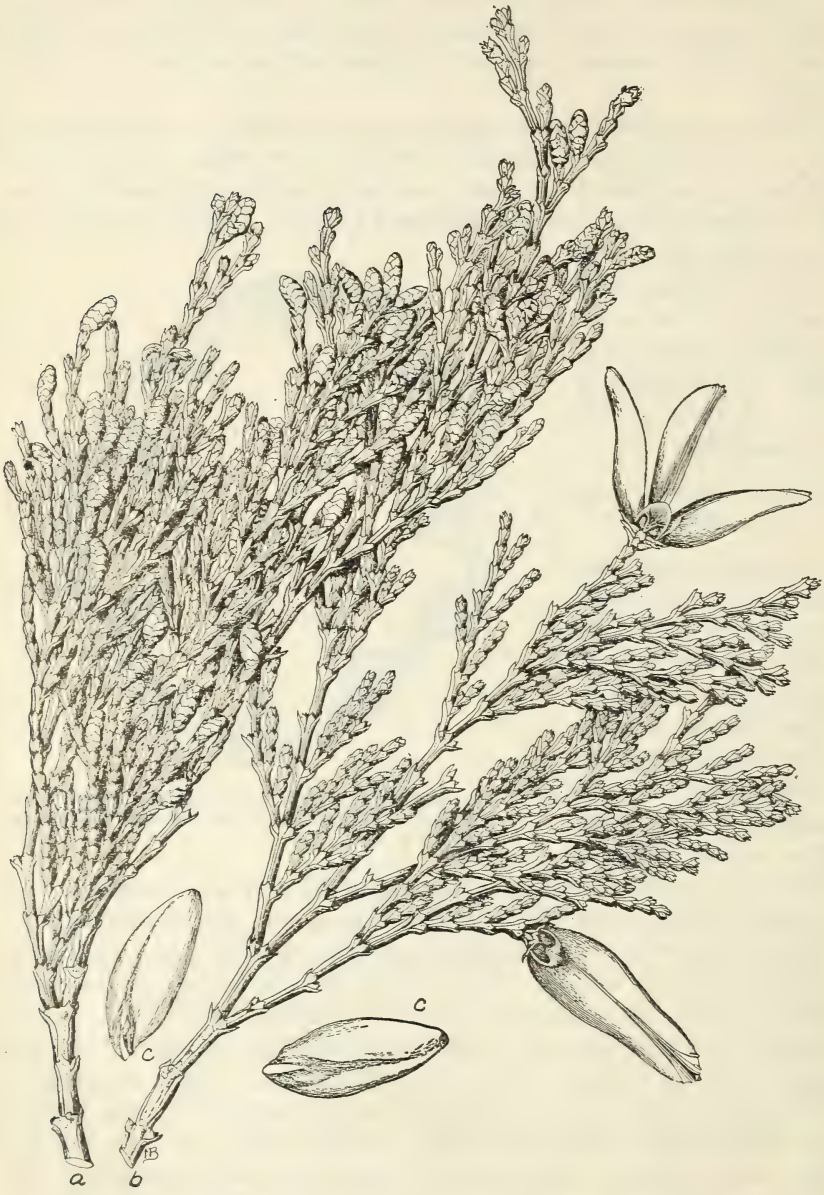


FIG. 3.—Libocedrus decurrens. *a*, male flowers; *b*, fruiting branch; *c*, seed.

elongated blunt point, and consist morphologically of three pairs of scales (practically only two, the two inner pairs being united), one pair of which bear fertile seed.

The seeds, two of which are borne normally at the base of each of the two seed-bearing scales, are small, light brown, and attached to a comparatively large wing measuring from three-eighths to one-half inch in length and from three-sixteenths to one-fourth inch in breadth. The lightness of the seeds, which weigh about 16,000 to the pound, and their relatively large wings adapt them to wide distribution by the wind. The wings are provided with glands containing a clear, red, pungently odorous resin which renders the seed more or less undesirable to rodents. This and the abundance and small size of the seed doubtless do much to insure the perpetuation of the species.

Incense cedar produces more or less seed annually, but good crops are not general oftener than once every three years. Thus, from the records available, we find that in 1906, 1909, 1912, and 1915 the seed crop was good, except in a few localities; whereas in the intervening years either little seed was produced or it was abundant only locally.

REPRODUCTION.

Incense cedar reproduces readily, and in good seed years abundantly. Tests on the seed, however, show a germination of only from 20 to 40 per cent. The seed is distributed in the fall and germinates early in the spring. Its ability to germinate in vegetable as well as mineral soil is advantageous in enabling it to get a foothold in deep litter, bear clover, and similar ground cover, where other species seem unable to start. It is even found growing in old stumps and rotten logs, where it often reaches a considerable size before securing a foothold in the mineral soil. Its long, rapidly growing taproot doubtless aids it a good deal in doing this and does much to insure its survival during the first few years of its life.

Incense cedar ordinarily does not reproduce in the open or in dense shade, seeming to prefer the half light of a high forest or the yellow pine and black oak cover of the upper foothill zone. In early life it is exceedingly tolerant of shade, but requires more light for its full development as it grows older. Consequently, though it survives under dense shade, it is unable to compete with the faster growing pines or the more tolerant firs with which it is associated.

Drought is undoubtedly the seedlings' greatest enemy. The long dry season, extending in normal years from June 1 to October 15, causes many to succumb. In localities where actual counts have been made this loss has been found to amount to as much as 90 per cent, and in dry years it is practically complete.

A good seed year followed by a favorable season means an abundance of reproduction; in other years there is practically none. It is

not uncommon, therefore, to find reproduction occurring in even-aged stands separated by an interval of several years from trees older and younger.

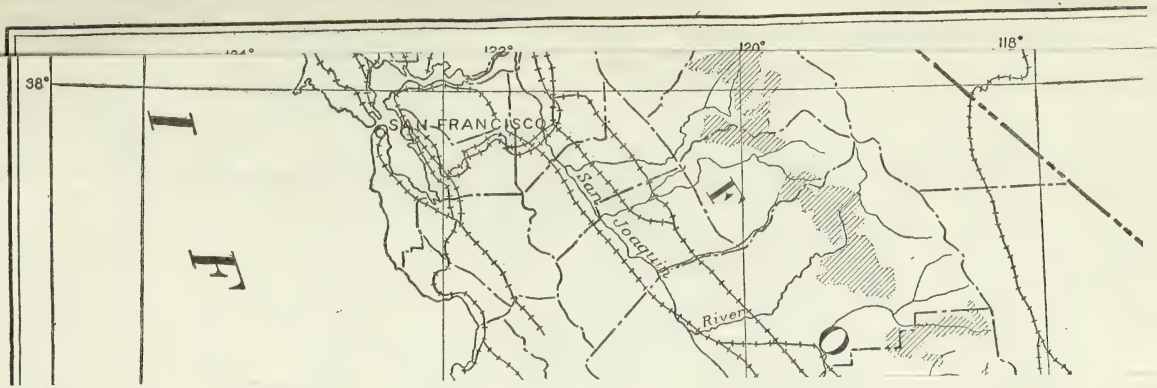
RANGE.

GEOGRAPHICAL.

Incense cedar, next to western yellow pine, adapts itself to a wider variety of conditions than any other tree native to California. It is found growing under almost every condition, and apparently is limited in distribution only by extreme drought, excessive humidity, and the conditions prevailing at high elevations. Its range is from northern Oregon to northern Mexico and from the eastern border of the fog belt in northern California nearly to the limits of commercial tree growth in western Nevada. Its northern limits are irregular, reaching as far north as Breitenbush Creek, on the west side of the Cascades, and to the foothills surrounding Mount Hood on the east side. It also is found on the Rogue-Umpqua divide in eastern Oregon, whence it extends south throughout the Siskiyous into northern California. In California it ranges between the foothills and the subalpine zones on both sides of the Sierras to the Kern River Valley and throughout the coast ranges at increasing elevations into northern Mexico and Lower California, where it finally disappears.

ALTITUDINAL.

East of the Cascades in northern Oregon the tree is found between altitudes of 2,000 and 3,000 feet, and in the southern part of the State between about 4,000 and 5,000 feet; on the west side of the Cascades it is abundant between 1,500 and 3,000 feet, and even higher in the warmer situations. In the coast ranges of California it occasionally goes as low as 1,100 feet, owing to heavier precipitation and an abundance of atmospheric moisture; but the bulk of it is found between 3,000 and 5,000 feet. In the mountains of northern California it grows between 2,500 and 6,000 feet, occasionally reaching as low as 1,000 feet where conditions are particularly favorable. It attains its best growth, however, between 3,000 and 6,000 feet. In the southern Sierras it is seldom found below 3,500 feet, and extends up to 7,000 or 7,500 feet, doing best between 4,000 and 6,800 feet. On the east slope, in extreme eastern California and western Nevada, its range is limited to the Warner Mountains and the northern and central Sierras, where it is confined between the 5,000 and 7,000 foot elevations. In the coast ranges of southern California and northern Mexico it grows still higher, the extreme aridity fixing its lower limit at about 4,000 feet and forcing it up as high as 9,000 or 9,500 feet at its southern limits.


122°
120°
118°
38°
SAN FRANCISCO
San Joaquin River

11919°—17. (To face page 20.)

FIG. 4.—Range of incense cedar.

A gradual increase in elevation from north to south is apparent, ranging from between 1,100 and 5,000 feet at its northern limits to between 4,000 and 9,000 feet at its southern. Similarly a rise is noticeable from west to east, the limit in the coast ranges being 1,100 and 5,000 feet, on the west slope of the Sierras 3,000 and 7,000 feet, and in western Nevada 5,800 and 7,000 feet.

SILVICAL REQUIREMENTS.

MOISTURE.

The minimum water requirement of incense cedar is low compared with other commercial timbers, as is shown by its frequent occurrence on dry, exposed ridges and at the extreme lower limits of commercial tree growth. It does best, however, where the supply of soil moisture is fairly abundant. In its drought-resisting qualities it is second only to western yellow pine among the commercially important species of its range; but extreme drought serves effectually to shut it out and, more than any other factor, prevents it from spreading to lower elevations. Excessive moisture, on the other hand, is equally effective in limiting its range. Hence we do not find it encroaching on wet mountain meadows or extending any great distance into the regions of excessive precipitation of the Pacific Northwest.

Soil moisture and humidity complement each other to a certain extent, it being possible for an abundance of one to make up partially for a lack of the other. Where soil moisture is sufficiently abundant, however, incense cedar will grow in an almost arid climate, showing that no great amount of humidity is essential.

LIGHT.

Incense cedar is a shade-enduring tree and reaches its best development in fairly dense stands. It is surpassed in tolerance only by white fir and possibly, in northern California and southern Oregon, by Douglas fir. The reluctance with which it sheds its lower limbs is an indication of this extreme tolerance. To kill out incense cedar by shading is almost impossible, though, of course, too much shade hinders growth, and an abundance of light, if other conditions are favorable, helps it.

TEMPERATURE.

Temperature is undoubtedly an important factor in the distribution of incense cedar, particularly in limiting its range at the higher elevations. The extreme cold, combined with the short growing season, is probably responsible more than any other factor for ex-

cluding this tree from the higher mountains. To a limited extent, heat may have some influence in fixing its lower limits. However, in view of the continued high temperatures which the tree is known to endure, it is doubtful whether heat has this effect, except as it reduces an already meager supply of moisture by causing excessive evaporation.

SOIL.

Of all the various factors affecting the occurrence of incense cedar, soil is probably the least important. The best proof of its adaptability in this respect is the fact that throughout its range it is found growing on soils of every description, bowlder wash and wet adobe excepted.

GROWTH.

Incense cedar is naturally a slow-growing tree. Under favorable conditions, however, its growth is fairly rapid, although it can not compete successfully with its more aggressive associates, sugar pine, yellow pine, and white fir.

HEIGHT GROWTH.

Table 12, which is based on stem analysis of 1,000 seedlings, shows the extremely slow growth of this species during the seedling stage under the average conditions prevailing in virgin stands.

TABLE 12.—*Incense cedar, seedling growth (age–height); basis, 1,000 seedlings.*

[CURVED.]

Age.	Height in feet.			Age.	Height in feet.		
	Average heights of all seedlings below the mean.	Mean. height.	Average heights of all seedlings above the mean.		Average heights of all seedlings below the mean.	Mean. height.	Average heights of all seedlings above the mean.
Years.				*Years.*			
5	0.2	0.5	1.0	25	1.7	2.7	5.1
10	.5	1.1	2.0	30	2.1	3.3	.....
15	.9	1.6	2.9	35	2.6	3.9	.....
20	1.3	2.2	3.9				

Under ordinary conditions, suppression is doubtless responsible to a large extent for this extremely slow growth, since reproduction, as a rule, occurs only in small openings or under the half light of a high forest, where the encouragement for rapid growth is small. In the larger openings and on cut-over lands, where light is abundant seedlings shoot up rapidly after they have once become thoroughly established. In fact, in all cases except those of extreme

suppression the seedling stage is followed by a period of more or less rapid height growth.

Incense cedar, under ordinary conditions, makes its fastest height growth between the ages of 40 and 150 years, growing most rapidly between the fiftieth and seventy-fifth years. When the maximum has once been reached, however, height growth falls off rapidly until at about 100 years the periodic or current annual growth falls below the mean annual growth. Beyond 150 years, growth in height is merely nominal. While height growth varies in amount in different localities, the above statements held true in every case studied, except one on the Plumas National Forest. Here, while the rate of height growth at no time equaled the maximum in other localities, the period of height growth was prolonged considerably, continuing at a fair rate up to 300 years of age.

TABLE 13.—*Height growth of incense cedar.*

[CURVED.]

Age.	Locality.				Average of all above the mean.	Average of all below the mean.	Mean.	
	Eldorado.	Plumas.		Stanislaus.			Total height.	Basis number of measurements.
		T. 24 N., R. 5 E.	T. 24 N., R. 10 E.					
	Total height (feet).							
Years.							*Feet.*[1]	
60	52	.....	.....	.....	58	12	23	46
80	67	.....	.....	.....	73	29	49	
100	78	52	61	.....	84	43	65	
120	86	63	70	.....	92	53	75	177
140	92	74	77	95	98	60	82	
160	97	83	82	100	102	67	86	
180	100	90	86	104	105	71	90	
200	104	96	89	108	108	76	93	
220	106	101	91	112	111	79	96	196
240	109	106	93	116	113.5	82	98	
260	112	109.5	95	119	116	85	101	
280	114	113	96.5	122	118	88	103	
300	116	116	98	124	119.5	89.5	105	
320	118	119	99	127	121	91	106	96
340	120	121	100	129	122.5	92.5	108	
360	.....	123	101	.....	124	94	109	
380	.....	125	102	.....	125.5	95.5	110	
400	.....	126	103	.....	127	97	111	
Basis number of measurements	60	90	319	34	.....	.....	.....	[2] 515

[1] Figures rounded off to the nearest foot.

[2] The difference between this figure and the total number of measurements indicated for the different localities is due to the inclusion of additional measurements, more or less scattered, from other localities in deriving the mean.

DIAMETER GROWTH.

Rapid diameter growth is confined largely to early life, although under favorable circumstances it continues for a considerably longer period than rapid height growth. Under ordinary conditions it

continues for about 200 years, after which it drops off, slowly at first, but more and more rapidly as old age approaches. The period of maximum diameter growth follows closely the period of maximum height growth, beginning about the time height growth culminates. The maximum rate is attained shortly after the periodic annual height growth falls below the mean.

Table 14 gives, for the sake of comparison, the average diameters breasthigh at different ages for trees growing in different localities. Considerable difference will be noted in the growth rate prevailing in the localities represented, but it also will be found that the period of rapid growth corresponds closely in every case.

TABLE 14.—*Diameter growth of incense cedar outside bark at breastheight.*

[CURVED.]

Age.	Locality.								Average.
	Eldorado National Forest.	Plumas National Forest (T. 24 N., R. 5 E.).	Shasta National Forest.	Modoc National Forest.	Kern National Forest.	Tahoe National Forest.	Plumas National Forest (T. 24 N., R. 10 E.).	Klamath National Forest.	
	Diameter breasthigh outside bark.								
Years.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
30	1.6	0.1	1.4	0.4	1.6	1.1	1.2	1.0	1.3
40	3.8	2.1	3.4	1.8	3.8	2.5	3.8	2.3	3.2
60	8.7	5.4	7.2	5.2	6.3	5.3	5.7	5.0	6.4
80	13.9	8.7	11.4	9.0	12.9	8.1	8.9	8.0	9.8
100	19.2	12.6	16.0	12.8	17.2	11.1	12.2	10.7	13.6
120	23.6	17.4	20.0	16.6	20.9	14.1	15.5	13.5	17.8
140	27.0	23.2	23.4	20.1	24.0	17.0	18.4	16.2	21.3
160	29.7	25.4	26.2	23.0	26.7	19.7	20.8	18.9	23.6
180	31.8	27.8	28.4	25.5	28.9	22.0	22.5	20.3	25.7
200	33.5	30.2	30.6	28.0	30.8	24.0	24.0	23.0	27.8
220	35.2	32.5	32.6	30.3	32.4	25.8	25.3	24.4	29.8
240	37.0	34.6	34.6	32.6	33.8	27.5	26.6	25.7	31.7
260	38.7	36.6	36.6	34.8	35.0	29.1	27.9	27.0	33.6
280	40.4	38.5	38.4	37.0	35.9	30.5	29.9	28.3	35.4
300	.....	40.1	40.0	.....	36.9	31.9	30.2	29.6	36.9
320	.....	41.7	41.4	.....	37.7	33.1	31.1	31.0	38.2
340	.....	43.1	42.5	.....	38.6	34.3	31.9	32.3	39.2
360	.....	44.4	.....	.....	39.4	35.3	32.5	33.5	40.1
380	.....	45.3	.....	.....	.....	.....	33.1	.....	40.9
400	.....	46.0	.....	.....	.....	.....	33.7	.....	41.6
Basis number of stump analysis	27	100	37	26	23	20	101	26	360

VOLUME GROWTH.

The cubic contents of the entire stem and the board-foot contents of the merchantable portion of trees of different ages grown in virgin stands are given in Table 15, together with the average heights and diameters on which these volumes are based.[1]

[1] Complete volume tables will be found in the Appendix.

TABLE 15.—*Growth in diameter, height, and volume of incense cedar.*

[CURVED.]

Age.	Average diameter outside bark at breast-height.	Average total height.	Volume.[1]	
			Cubic feet outside bark.	Board feet (Scribner Dec. C).
Years.	*Inches.*	*Feet.*		
100	13.6	65.0	32	70
110	15.8	70.0	44	100
120	17.8	75.0	56	140
130	19.9	79.0	68	190
140	21.3	82.0	80	230
150	22.5	84.0	92	270
160	23.6	86.5	103	310
170	24.7	88.0	114	340
180	25.7	90.0	126	390
190	26.8	91.5	138	440
200	27.8	93.0	150	490
210	28.8	94.5	163	540
220	29.8	95.5	176	600
230	30.8	97.0	190	670
240	31.7	98.5	204	720
250	32.7	99.5	219	790
260	33.6	100.5	234	850
270	34.5	101.5	250	900
280	35.4	103.0	264	970
290	36.2	104.0	278	1,030
300	36.9	104.5	290	1,090
310	37.6	105.5	302	1,160
320	38.2	106.5	313	1,200
330	38.7	107.0	323	1,240
340	39.2	107.7	333	1,290
350	39.7	108.5	342	1,340
360	40.1	109.0	350	1,380
370	40.5	109.5	359	1,410
380	40.9	110.0	367	1,440
390	41.3	111.0	375	1,480
400	41.6	111.5	383	1,510
Basis...	[2] 360	[3] 515	.....	.....

[1] Volumes given are based on volume-table values for corresponding heights and diameters.
[2] Stump analyses.
[3] Measurements.

The period of most rapid volume growth occurs later in life than the period of either rapid height or rapid diameter growth. The maximum periodic growth is reached at an age of about 275 years, after which increment falls off rapidly, dropping below the mean annual increment at about 345 years. The mean annual increment, however, increases gradually until an age of about 300 years is reached, after which it remains fairly constant, declining but slightly in the next 100 years. This, it should be remembered, is true of the growth of individual forest-grown trees only. The growth in volume of stands culminates much earlier and has no direct relation to that of individual trees.

Table 16 shows how incense cedar compares with sugar pine and yellow pine in rate of growth and why it can not compete successfully with these species in mixed stands.

TABLE 16.—*Comparative rate of growth of sugar pine, yellow pine, and incense cedar.*

Age.	Sugar pine.			Yellow pine.[1]			Incense cedar.		
	Diameter breast-high.	Height.	Volume.	Diameter breast-high.	Height.	Volume.	Diameter breast-high.	Height.	Volume.
Years.	*Inches.*	*Feet.*	*Board feet.*	*Inches.*	*Feet.*	*Board feet.*	*Inches.*	*Feet.*	*Board feet.*
20	0.2	8	.....	2.3	12	.....	.....	.....	.....
40	2.5	23	.....	6.5	29	.....	3.2	.....	.....
60	7.5	45	.....	11.4	57	.....	6.4	23	.....
80	13.0	72	110	16.1	79	210	9.8	49	.....
100	18.1	92	240	20.0	94	360	13.6	65	70
120	22.7	106	490	23.3	104	610	17.8	75	140
140	26.8	118	850	25.8	112	890	21.3	82	230
160	30.5	127	1,290	28.0	118	1,170	23.6	86	310
180	33.9	135	1,760	29.8	123	1,430	25.7	90	390
200	37.0	142	2,250	31.3	127	1,640	27.8	93	490
220	40.0	148	2,830	.....	.....	.....	29.8	96	600
240	42.5	153	3,460	.....	.....	.....	31.7	98	720
260	44.9	158	4,120	.....	.....	.....	33.6	101	850
280	47.2	162	4,840	.....	.....	.....	35.4	103	970
300	49.3	167	5,570	.....	.....	.....	36.9	105	1,090
320	51.4	171	6,020	.....	.....	.....	38.2	106	1,200
340	53.5	174	7,050	.....	.....	.....	39.2	108	1,290
360	55.5	177	7,740	.....	.....	.....	40.1	109	1,380
380	57.3	180	8,380	.....	.....	.....	40.9	110	1,440
400	59.1	183	9,010	.....	.....	.....	41.6	111	1,510

[1] From Forest Service Bulletin 69, "Sugar Pine and Western Yellow Pine in California," by Albert W. Cooper.

GROWTH IN EVEN-AGED STANDS.

Growth in diameter, height, and volume in even-aged stands is, as might be expected, much more rapid than that prevailing in virgin all-aged stands, where competition for light and growing space is keen. As is shown in Table 17, which is based on measurements gathered in Madera, Tuolumne, and Yuba Counties, this difference is considerable. Unfortunately, no mature even-aged stands exist, and only general conclusions can be drawn as to the growth in later life under such conditions. It is evident, however, that incense cedar would make much better growth in even-aged stands than in the all-aged virgin forests.

TABLE 17.—*Average growth of individual trees in even-aged stands; basis, 35 trees.*

[CURVED.]

Age.	Total height.	Diameter breast-high outside bark.	Volume.
Years.	*Feet.*	*Inches.*	*Cubic feet.*
10	5.5	.....	.....
20	15.5	3.1	0.5
30	30.0	6.3	1.3
40	43.5	9.2	4.2
50	53.0	11.7	9.9
60	60.0	13.6	17.2
70	64.0	14.9	26.0
80	67.0	15.9	31.6

GROWTH AFTER CUTTING.

Examinations of recent cuttings on lands culled over 30 or 40 years ago indicate that the ability of incense cedar to recover from suppression is slight, once the period of rapid diameter and height growth is passed. Up to the present, however, observations have been too limited to justify definite conclusions, and further study will be necessary before its possibilities in this respect can be determined conclusively.

FOREST TYPES AND ASSOCIATED SPECIES.

Incense cedar is confined to two main forest types—the semiarid or western yellow-pine type and the middle-slope or mixed-conifer type. The first, in which yellow pine or Jeffrey pine predominates and incense cedar is represented sparingly, forms a narrow belt in the upper foothill zone, on the west slope of the Sierras and the east slope of the northern coast ranges, between the digger pine and the chaparral of the foothills and the mixed conifer stands of the timber belt. This type also is found in a modified form on the lava beds in northeastern California, where it covers large areas, and on the east slopes of the Sierras, where it again forms a border along the lower edge of the commercial timber zone.

Most of the incense cedar, however, is found in the mixed conifer forests of the middle slopes. This type is of varying composition, being made up of western yellow pine, Jeffrey pine, sugar pine, white fir, Douglas fir, and incense cedar in all proportions. In the southern Sierras Douglas fir is absent; in central and northern California it appears in constantly increasing proportions toward the north until, in the Siskiyous, it is the predominating species. From lower to higher elevations, too, the composition varies, the pines predominating at first, only to give way to the firs higher up. A variation of the mixed-conifer type of the middle slope occurs on the east slope of the Sierras, where Jeffrey pine and white fir predominate and incense cedar occurs scatteringly.

Incense cedar is sometimes found in the lower subalpine zone mixed with white fir, red or Shasta fir, lodgepole pine, and even western white pine. At lower elevations, where lodgepole pine occurs in the vicinity of mountain meadows, incense cedar grows near by on the drier portions of the site, but seldom mixes with it.

At its extreme lower limits, where it is confined to ravines and watercourses, incense cedar occurs occasionally with yew and California nutmeg; and in the coast ranges it occurs with a number of broadleafed trees, among which are the broadleafed maple, alders, willows, dogwood, madroña, chinquapin, and tanbark oak.

Throughout the upper foothill belt on the west slope of the Sierras, California black oak is a particularly common associate of

incense cedar, being found throughout the yellow-pine and lower mixed-conifer zones. Other oaks also are found with it, although not so extensively.

Bigtree or mountain redwood (*Sequoia washingtoniana*) also occurs within the range of incense cedar, and is associated more or less intimately with it wherever found.

In southern California incense cedar associates most frequently with western yellow, Jeffrey, and sugar pine. Here at the upper limits of its range it also mixes with white fir and occasionally with lodgepole or limber pine, while below the commercial timber belt it is found growing with big-cone spruce, piñon, coulter pine, and western juniper.

STAND.

Owing to the scattered occurrence of incense cedar, figures as to stand and yield have little general application, since the widest variations frequently occur in the same locality and the species seldom, if ever, predominates in the stand. As an example, however, of actual conditions, the average stand of cedar in the mixed-conifer type on the Plumas National Forest, based on an intensive reconnaissance of 2,200 acres, is given in Table 18.

TABLE 18.—*Average stand of incense cedar per acre, mixed-conifer type, Plumas National Forest; average of 2,200 acres, from reconnaissance data.*

Diameter breasthigh (inches).	Number of trees per acre, incense cedar.	Per cent of total number of incense cedars in each diameter class.	Per cent of incense cedar in the stand by diameter classes based on number of trees.
12	0.36	7.5	21.1
14	.32	6.6	20.0
16	.36	7.5	23.3
18	.39	8.2	24.2
20	.48	10.5	24.6
22	.45	9.3	27.2
24	.45	9.3	23.9
26	.37	7.8	21.9
28	.26	5.5	22.8
30	.29	6.1	23.5
32	.35	7.2	27.5
34	.17	3.4	20.6
36	.17	3.4	27.3
38	.11	2.2	19.5
40	.01	1.5	16.5
42	.11	2.2	33.1
44	.03	.6	13.1
46	.06	1.2	30.1
48	.01	.0	5.0
50			
52	.01		12.0
Total	4.82	100.0	23.1

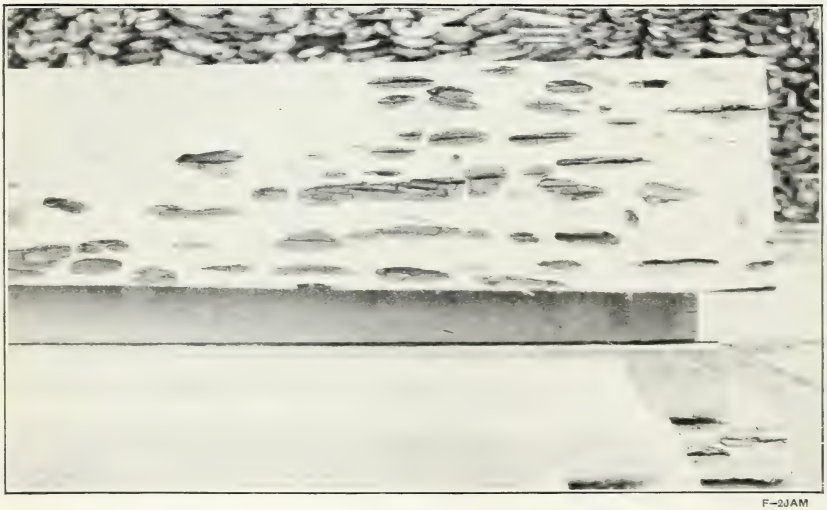
Expressed in terms of volume, the average stand of incense cedar was 2,329 feet, board measure, per acre or about 14 per cent of the total volume.

F-99523

INCENSE CEDAR (X) GROWING IN A TYPICAL OPEN STAND OF WESTERN YELLOW PINE, SUGAR PINE, AND FIR.

F-1JAM

FIG. 1.—BUTT OF A CULL INCENSE CEDAR LOG, SHOWING TYPICAL DRY-ROT.



F-2JAM

FIG. 2.—CULL PLANK OF INCENSE CEDAR, SHOWING THE RESULT OF DRY-ROT.

ENEMIES.

DISEASE.[1]

Incense cedar is subject to few diseases, but three of these are very common. They are caused by a mistletoe (*Phoradendron juniperinum libocedri*), a rust fungus (*Gymnosporangium blasdaleanum*), and the dry-rot fungus (*Polyporus amarus*). The only serious damage to merchantable trees, however, is due to the latter.

Polyporus amarus attacks the heartwood of mature living trees only, trees below the age of 140 years being more or less immune. Thrifty growing trees in damp, rich soils seem to be less affected than slow-growing ones on dry, poor sites; and trees with large wounds are far more likely to be pecky than intact ones.

The large annual fruiting bodies (sporophores or conchs) of *Polyporous amarus* invariably grow out of branch holes or pin knots, never through the bark. The mature conch has the shape of a bell cut lengthwise in halves. The upper side is light tan in color, the under side a brilliant yellow, turning brown with age. Spores are formed in enormous numbers and are carried by air currents to other trees. They germinates only when they land on a wound or opening leading to the heartwood. Thus fire scars and branch stubs very often offer them an easy entrance. The fungus attacks the heartwood, honeycombing it with cavities from one-quarter inch to an inch in diameter by from an inch to several feet in length. These cavities are filled with a dry, brown, charcoal-like substance which characterizes this defect and gives it its name of "dry" or "brown" rot. The wood between the cavities is usually sound.

It is often impossible to detect the presence of dry-rot from the outward appearance of the tree, but there are certain infallible signs by which we can tell that the timber is infected. The presence of a fruiting body of *Polyporus amarus*, of course, indicates beyond a doubt that the fungus is at work in the heartwood. But the fleshy annual fruiting bodies are devoured eagerly by squirrels and the larvæ of a small moth that afterwards burrows through into the dead bark. Later, woodpeckers chop out these larvæ, so that, finally, a cup-shaped depression, pierced with numerous larvæ holes, is formed in the bark where the fruiting body once was. These depressions are a certain sign of decay, and their number and appearance indicate the extent of the dry-rot in the interior of the tree. In general, the decay is more pronounced in the lower part of the tree, since the fungus very commonly starts from fire scars.

Since the entrance of the dry-rot fungus into the heartwood can in a great number of cases be traced to fire scars, fire prevention and

[1] Prepared by Dr. E. P. Meinecke, pathologist, Bureau of Plant Industry.

control is the first step in eliminating the disease. Where possible, also, trees with large wounds, whether from fire or otherwise, should be marked for cutting in preference to sound ones, and no trees with a fruiting body of *Polyporus amarus* or with the cup-shaped depressions described above should be left standing.

FIRE.

Repeated ground fires are responsible for considerable damage throughout the range of incense cedar, and few mature trees are to be found that do not show some evidence of this in burned butts and cat faces. In some regions fire damage has been extreme, practically every tree being hollowed out at the base or felled by repeated fires. The thick bark of this species and its rather fire-resistant foliage offer considerable protection to mature trees; but severe fires, especially where there is an accumulation of débris, do a great deal of damage, since the somewhat resinous bark burns like punk, and a fire once started in it often burns for a long time. Repeated fires eat into the tree, each successive fire enlarging the wound already made and increasing the danger of infection from disease. Incense cedar is, however, persistent, seldom succumbing to fire alone unless completely girdled or so burned out at the base that it falls through lack of mechanical support. Burning stimulates the natural tendency of the tree to buttress, extraordinary growth frequently being made in this way in an attempt to overcome the damage done.

In stands of young cedar damage from fire is usually more severe, owing to the thinner bark and the greater exposure of the crown to the heat of the flames. Although somewhat more fire resistant than the more resinous pines, its power of recovery is less, and it ranks after yellow and sugar pine, owing apparently to a lower fire resistance of the terminal buds. As a consequence, an incense cedar when scorched is usually as severely damaged as appears at first, while pines frequently recover entirely in a year or two, though at first the entire crown apparently has been killed.

The greatest damage by ground fires is to reproduction. No matter how light the fire, the smaller seedlings, growing half buried in the litter, are destroyed, and no future stand can be expected where the practice of light burning is followed or adequate fire protection is not given.

INSECTS.

Incense cedar rarely is killed by insect infestation, except in the seedling and sapling stage. Like the sequoias, mature trees are practically immune from attacks causing death in one season. Mature

trees are, however, sometimes killed by repeated attacks of several species of beetles, and individual trees or small stands of cedar reproduction are often killed by a species of *Phloeosinus*. Trees attacked by this beetle are killed outright in one summer, turning pale yellow by July and generally dying by October 1. To control insects in reproduction, all infested trees should be felled and burned during the fall, winter, or spring months before the beetles have emerged.

When numbers of trees are found dying and there is evidence of primary insect injury the matter should be reported to the Bureau of Entomology with specimens of the insect or its work and request for information on the proper action to be taken.

SNOW, WIND, GRAZING, ETC.

As incense cedar occurs in close stands and more or less protected situations, snow and wind probably would cause comparatively little damage were it not for the brittleness of the tops and branches. As it is, exposed trees invariably show the effects of snow and high winds by irregular one-sided crowns and broken or distorted tops. Considerable damage also is done to young timber when a heavy fall of wet snow is followed by high winds, the brittle branches and tops being frequently snapped off. Throughout its life, however, incense cedar is highly persistent in endeavoring to overcome this handicap by sending up new leaders, a tendency which results in the characteristic pronglike tops so common on this species.

Incense cedar is probably subject to less damage from logging than any of its associated species, the seedlings and smaller saplings being tough, firmly rooted, and able to survive considerable hard usage. For the same reasons and because of the protection offered by the resinous, highly pungent foliage, which renders it less palatable than its associates, it is seldom damaged by sheep and cattle.

MANAGEMENT.

GENERAL POLICY ON NATIONAL FORESTS.

At the time the Forest Service first undertook the administration of the National Forests incense cedar was regarded as a weed tree; and, in early sales of Government timber, efforts were made to eliminate it from the stand by marking it heavily for cutting. Later, as the excellent character of the lumber derived from it when sound became known, this policy was modified and sound thrifty trees were spared when they did not interfere seriously with the development of the more highly valued species. To-day, in view of its increasing value, incense cedar is receiving more consideration and its possibilities are being studied in an effort to determine the methods best adapted to insure its perpetuation and maximum development.

PROBLEM OF MANAGEMENT.

In view of the fact that for many years to come the Forest Service, as well as timber owners in the West generally, will be concerned primarily with the management of virgin forests, it is evident that the immediate problem is the utilization of the present crop of mature and overmature timber and the protection of second-growth stands against loss through fire and disease.

As has already been brought out, most of the merchantable incense cedar to-day consists of mature timber practically at a standstill as regards growth and more or less affected with dry-rot. The logical procedure, therefore, is to cut out as fast as practicable all mature and infected trees, disposing of them at a nominal price if necessary, in order to insure the health and soundness of the remaining stand. Such a policy is now practiced by the Forest Service in sales of Government timber and should be the policy of all private operators who are interested in the future of their holdings. By adequate fire protection and the elimination of all diseased timber as the forested areas are cut over, future stands and the young and thrifty growing stock already established can be prevented to a large extent from falling into the unfortunate condition now prevailing in virgin stands. Fortunately, under normal conditions, natural reproduction of incense cedar is excellent, so that protection from fire and a reasonable amount of care in cutting are all that is necessary to insure a perpetuation of the stand.

Next in importance, from the standpoint of management, is the encouragement of rapid growth and improved form in future stands of this species. Here the opportunity of the forester to overcome the obstacles presented is limited only by the maximum possibilities of the tree and the economic conditions which must be met in order to insure a reasonable return on the investment.

ROTATION.

Preliminary studies by Dr. E. P. Meinecke have shown that on the most favorable sites few trees below the age of 150 years are affected with dry-rot. It is probable, therefore, that with proper sanitation and adequate protection from fire little loss need be feared before this age is reached. This is sufficient time under ordinary conditions for cedar to grow to a diameter of about 2 feet. Under proper silvicultural treatment this size can be increased materially without exceeding the rotation thus established.

While under natural conditions incense cedar does not reach maturity until about the three hundred and forty-fifth year, it reaches merchantability, or a diameter of 28 inches, in about 200 years, and under favorable conditions for growth, such as might be expected to prevail in managed stands, in 150 years. This estimate is con-

servative for managed stands, since it is based entirely on what the tree has done in virgin stands. Though the most satisfactory rotation can not be determined definitely until stands have actually been brought under management, the above gives a working basis that is amply conservative.

SILVICULTURAL TREATMENT.

Incense cedar is naturally such a slow grower that in spite of its wide distribution and ready adaptability to various sites it can never be grown at a profit under any but the most favorable conditions. It would be folly to attempt to do so on sites where conditions are otherwise. It is even a question whether it should not be eliminated from the stand entirely on the sites less adapted to it, in order to favor as far as possible the species which can be counted on to produce an adequate return. Under the most favorable conditions and with proper handling incense cedar probably will yield returns equal to, or greater than, those of its associates because of its value for special uses.

In general, however, the management of incense cedar will have to be subordinated to that of its more important associates, since it is unlikely that the forests in which it occurs will ever be handled with the single purpose of securing the best conditions of growth for it alone, or that it will ever be grown over large areas. The following discussion, therefore, must be considered as outlining the ideal management for incense cedar rather than the one which at present is economically advisable.

Having adopted a rotation, the next question is how best to secure maximum development in the size and quality of the timber to be grown. Will incense cedar do best when grown with other species or when grown alone? Should it be grown in all-aged or in even-aged stands, and what silvicultural system will give the best results—selection cutting, clear cutting and planting, the shelterwood method, or the seed-tree method?

CHARACTER OF STANDS.

Incense cedar is a tree particularly well adapted to growing in mixture with other species. The fact that it is never found in pure stands, as well as its extreme tolerance, indicates this. On the other hand, its slow growth when suppressed and its fairly rapid growth, particularly in early life, when light, especially top light, is abundant, indicates that in even-aged stands the yield will be greater than in stands where all ages are represented and only the dominant trees receive full light. The study of growth in even-aged stands substantiates this conclusion.

SPECIES IN MIXTURE.

All things considered, yellow pine is probably the most desirable tree to grow in combination with incense cedar, for, although its growth is more rapid, its foliage is not so dense as to suppress the cedar materially during the first 75 or 100 years, and in close stands it aids materially in forcing height growth and in shading out the lower limbs, thus insuring a reasonably clear length. Sugar pine, owing to its more open crown, is probably not so well adapted to this purpose as yellow pine, and the firs (both white and Douglas), because of their rapid growth and denser foliage, would tend to suppress the cedar and thus materially retard its growth.

SILVICULTURAL SYSTEMS.

It is probable that some modification of the shelterwood or selection border cutting will give the best results, although to a large extent this will have to be worked out by actual field tests. The considerations leading to this conclusion are: (1) The fact that incense cedar is an abundant seed producer, (2) that reproduction is established readily under a high forest but not so readily under a dense cover or in the open, (3) that in this way stands practically even aged can eventually be secured. Strictly even-aged forests over areas of any considerable extent can of course be secured only by planting, but this is out of the question under present economic conditions. A method of cutting, then, that will insure approximately even-aged stands is desirable.

On areas large enough in extent to be capable of producing a sustained yield sufficient to warrant continuous operations or cuts at frequent intervals, say, every 5 or 10 years, the selection border cutting or a progressive thinning of successive strips would seem to be most advisable. This system allows the gradual opening up of the forest, thus insuring satisfactory stocking and progressively even-aged stands. On small areas, to be cut over only at long intervals or at the end of the rotation, a modification of the shelterwood system, which would provide for an opening up of the stand by the removal of the nurse trees and larger cedars at the time growth ordinarily begins to fall off, probably would give the most satisfactory results. The period of rapid development could thus be prolonged and the establishment of a second crop as an understory assured.

While the silvicultural systems named above are applicable in general, the details necessarily will have to be worked out in each particular case. A feature in favor of these methods, however, is their flexibility, which not only makes possible such modifications as are necessary to meet local conditions, but also such changes as may be necessary to meet variations in the silvicultural condition of the stand or fluctuations of the market.

ARTIFICIAL FORESTATION.

SEED COLLECTING.

GATHERING THE SEED.

The seed of incense cedar matures usually during the latter part of September or the first three weeks of October. The ripe cones may be gathered from the trees and the seed extracted later, or by spreading canvas or blankets beneath the trees and vigorously thrashing the branches the seed may be collected direct.

EXTRACTING AND CLEANING SEED.

Where the cones have been collected from the trees it is necessary to extract the seed artificially. This is usually done by spreading the cones on canvas or blankets in the sun until they open, which requires about three days, and then thrashing out the seed by hand. In stormy weather a drying house and artificial heat are necessary.

It is desirable to remove the wings from the seed, so far as is possible, and this may be accomplished in a measure by rubbing them vigorously between the hands, thus breaking off the greater portion of the wing. As a rule, however, this is not done, the seed simply being separated from the chaff and light nonfertile seed by means of a fanning mill fitted with screens of the proper mesh, or by pouring the seed from one box to another in a current of air.

YIELD AND COST OF SEED COLLECTION.

Incense cedar seed is quoted by various seed dealers on the Pacific coast at from $1.65 to $4 a pound, and seed collected by the Forest Service in the past has cost from $1.50 to $2.25 a pound, according to the conditions under which the collecting was done. As to the yield to be expected, experience has shown that on the average from 2 to 3 pounds of clean seed can be secured from a bushel of cones, while the number of seed per pound averages about 16,000.

STORAGE.

Seed of this species keeps best if placed in bags and stored in a cool, dry, well-ventilated place. Since it is very apt to mold if large quantities are kept in one bag with insufficient ventilation, the bags should not be too large and they should be hung up rather than piled in a compact heap, a precaution which also guards against the depredations of rodents.

NURSERY PRACTICE.

Owing to its relatively low germination per cent (from 20 to 40), it is necessary to sow incense cedar seed comparatively heavily. On

the average, therefore, about 3 pounds is usually sown to each 100 square feet of seed bed, or 1½ pounds to each 100 linear feet of drill.

Under favorable conditions germination usually takes place in about three weeks and is fairly uniform, little if any of the fertile seed lying dormant. The seedling develops fairly rapidly for a conifer, and by the end of the first season is from 2 to 4 inches tall and has a root from 6 to 10 inches long. When 1 year old it usually is transplanted into beds or pots, and when 2 or 3 years old it is set out in the field, having by that time reached a height of from 6 to 10 inches. The cost of raising stock varies widely, but is proportionately less when large quantities are raised. At the Pilgrim Creek nursery on the Shasta National Forest, in 1912, the cost of raising 1-year-old seedlings was $7.63 per 1,000, including overhead charges, and it was estimated that 2-year-old stock one year in the transplant beds had cost approximately $13.35 per 1,000. Adding $2.98, the average cost of preparing for shipment and hauling to the railroad, gives the average cost of stock of this species when it left the nursery as $16.63 per 1,000. At other nurseries where stock has been raised in smaller quantities and transplanted into paper pots instead of transplant beds the cost has run as high as $27.50 per 1,000. There is little question, however, that stock of this species raised in commercial quantities could be produced at a cost considerably below these figures. For ornamental purposes, for which there is a growing demand, incense cedars bring 60 cents apiece when from 6 inches to 1 foot high and $1.50 when from 2 to 4 feet high.

FIELD PLANTING AND SOWING.

Repeated efforts have been made by the Forest Service to establish plantations of incense cedar by sowing both broadcast and in seed pots but with indifferent success, owing to damage by rodents and drought and to many of the sites being unfavorable. Where conditions are favorable, however, planting with this species gives fair promise of success. Too little work has yet been done to determine conclusively the possibilities of field planting, but there is every reason to believe that with proper methods incense cedar can be planted successfully. The cost, however, will have to be reduced materially before field planting can be done at a profit that will justify its being attempted on a commercial scale by private individuals.

APPENDIX.

TABLE 19.—*Volume, in cubic feet, of incense cedar, based on total height, Plumas, Sequoia, Shasta, and Stanislaus National Forests, California.*

[CURVED.]

Diameter breasthigh.	Total height of tree (feet).										Average total height.	Basis number of trees.
	60	70	80	90	100	110	120	130	140	150		
	Total volume, cubic feet, outside bark.											
Inches.											*Feet.*	
16	42	45	48	.....	.....	.....	.....	.....	.....	.....	54	1
17	44	48	52	.....	.....	.....	.....	.....	.....	.....	58	.....
18	49	54	58	62	68	.....	.....	.....	.....	.....	62	7
19	54	59	64	69	74	.....	.....	.....	.....	.....	66	.....
20	59	65	71	76	82	.....	.....	.....	.....	.....	69	18
21	66	72	78	83	90	.....	.....	.....	.....	.....	72	.....
22	72	79	86	92	99	108	.....	.....	.....	.....	75	36
23	79	86	94	100	108	118	.....	.....	.....	.....	78	.....
24	86	94	102	109	118	128	.....	.....	.....	.....	81	43
25	94	102	111	118	128	138	.....	.....	.....	.....	84	.....
26	102	111	120	128	138	149	.....	.....	.....	.....	86	44
27	110	119	129	138	149	160	.....	.....	.....	.....	89	.....
28	119	128	138	149	160	173	185	200	215	.....	91	65
29	128	138	148	159	173	185	200	215	230	.....	93	.....
30	137	147	158	170	184	199	214	230	246	.....	95	84
31	147	157	168	182	196	213	228	245	262	.....	97	.....
32	156	167	189	193	209	227	242	260	278	.....	99	92
33	.....	.....	191	207	223	241	257	276	294	.....	101	.....
34	.....	.....	202	220	237	256	272	292	311	.....	103	81
35	.....	.....	216	233	251	271	288	308	328	.....	105	.....
36	.....	.....	227	247	265	286	304	325	347	.....	107	102
37	.....	.....	241	261	281	302	321	343	365	.....	109	.....
38	.....	.....	254	275	296	317	338	361	384	404	111	100
39	.....	.....	268	290	312	334	356	380	404	426	112	.....
40	.....	.....	283	305	327	350	374	398	424	442	114	62
41	.....	.....	297	320	343	367	393	428	445	470	116	.....
42	.....	.....	312	336	360	385	412	438	466	493	117	67
43	.....	.....	327	351	376	403	432	458	488	515	119	.....
44	.....	.....	341	367	393	421	450	479	519	539	120	75
45	.....	.....	.....	.....	410	440	470	500	531	563	122	.....
46	.....	.....	.....	.....	428	460	490	522	554	588	123	56
47	.....	.....	.....	.....	446	480	510	543	577	614	124	.....
48	.....	.....	.....	.....	469	500	530	565	601	649	125	33
49	.....	.....	.....	.....	483	519	551	587	625	665	126	.....
50	.....	.....	.....	.....	501	540	572	610	650	692	127	30
51	.....	.....	.....	.....	.....	.....	594	634	676	719	128	.....
52	.....	.....	.....	.....	.....	.....	617	658	702	747	129	21
53	.....	.....	.....	.....	.....	.....	640	683	728	774	130	.....
54	.....	.....	.....	.....	.....	.....	664	709	755	803	131	8
55	.....	.....	.....	.....	.....	.....	688	735	782	832	132	.....
56	.....	.....	.....	.....	.....	.....	712	762	809	862	133	12
57	.....	.....	.....	.....	.....	.....	738	789	838	893	134	.....
58	.....	.....	.....	.....	.....	.....	763	817	869	925	134	8
59	.....	.....	.....	.....	.....	.....	788	845	901	960	135	.....
60	.....	.....	.....	.....	.....	.....	815	875	934	995	136	7
61	.....	.....	.....	.....	.....	.....	842	904	966	1,030	136	.....
62	.....	.....	.....	.....	.....	.....	868	934	1,000	1,065	137	2
Total basis	38	170		327		331		155		33	.....	1,054

TABLE 20.—*Volume, in board feet, of incense cedar, based on total height, Plumas, Sequoia, Shasta, and Stanislaus National Forests, California.*

[CURVED.]

Diameter breasthigh.	Total height of tree (feet).																	Average height of tree.	Diameter inside bark of top.	Basis.
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200			
	Volume (board feet).																			
Inches.																		*Feet.*	*Inches.*	*Trees.*
16	50	60	80	100	110	120	140	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	54	8	2
17	60	70	90	110	130	140	160	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	58	8	9
18	60	90	110	130	150	170	190	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	62	9	.....
19	70	100	120	150	170	200	220	240	.....	.....	.....	.....	.....	.....	.....	.....	.....	66	9	20
20	80	120	140	170	190	220	240	270	.....	.....	.....	.....	.....	.....	.....	.....	.....	69	9	.....
21	100	130	160	190	220	240	270	300	.....	.....	.....	.....	.....	.....	.....	.....	.....	72	9	37
22	110	150	180	210	240	270	300	330	370	.....	.....	.....	.....	.....	.....	.....	.....	75	9	.....
23	130	160	200	230	260	300	330	350	410	.....	.....	.....	.....	.....	.....	.....	.....	78	9	43
24	140	180	220	250	290	330	360	410	450	.....	.....	.....	.....	.....	.....	.....	.....	81	9	.....
25	160	200	240	280	320	360	400	450	510	560	.....	.....	.....	.....	.....	.....	.....	84	9	44
26	170	220	270	310	350	400	450	500	560	620	.....	.....	.....	.....	.....	.....	.....	86	9	.....
27	190	240	290	340	380	440	490	550	620	680	.....	.....	.....	.....	.....	.....	.....	89	9	67
28	210	260	320	370	420	480	540	610	680	740	810	.....	.....	.....	.....	.....	.....	91	9	.....
29	.....	290	350	400	460	520	590	660	740	800	880	.....	.....	.....	.....	.....	.....	93	9	87
30	.....	320	380	440	500	570	640	720	800	870	950	.....	.....	.....	.....	.....	.....	95	9	.....
31	.....	350	410	480	540	620	700	780	860	940	1,020	1,110	.....	.....	.....	.....	.....	97	9	96
32	.....	380	450	520	590	670	760	840	920	1,010	1,100	1,190	.....	.....	.....	.....	.....	99	10	.....
33	.....	.....	480	560	640	720	810	900	990	1,080	1,170	1,280	.....	.....	.....	.....	.....	101	10	84
34	.....	.....	520	600	680	770	870	960	1,060	1,160	1,250	1,360	1,470	.....	.....	.....	.....	103	10	.....
35	.....	.....	560	640	730	820	920	1,020	1,130	1,230	1,340	1,450	1,560	.....	.....	.....	.....	105	10	104
36	.....	.....	590	680	780	880	980	1,090	1,200	1,310	1,420	1,540	1,660	.....	.....	.....	.....	107	10	.....
37	.....	.....	.....	730	830	940	1,050	1,160	1,280	1,390	1,510	1,640	1,760	1,880	.....	.....	.....	109	10	102
38	.....	.....	.....	780	880	1,000	1,110	1,230	1,350	1,470	1,600	1,730	1,860	1,980	.....	.....	.....	111	10	.....
39	.....	.....	.....	830	940	1,060	1,180	1,300	1,430	1,560	1,690	1,830	1,960	2,090	.....	.....	.....	112	10	63
40	.....	.....	.....	880	1,000	1,120	1,250	1,380	1,510	1,640	1,780	1,920	2,060	2,200	2,340	.....	.....	114	10	.....
41	.....	.....	.....	.....	1,060	1,180	1,320	1,450	1,590	1,730	1,880	2,020	2,160	2,310	2,460	.....	.....	116	10	67
42	.....	.....	.....	.....	1,120	1,250	1,390	1,530	1,680	1,820	1,970	2,120	2,270	2,430	2,580	.....	.....	117	10	.....
43	.....	.....	.....	.....	1,180	1,320	1,460	1,610	1,760	1,910	2,070	2,220	2,380	2,550	2,710	2,860	.....	119	10	76
44	.....	.....	.....	.....	1,250	1,390	1,540	1,700	1,840	2,000	2,170	2,320	2,490	2,660	2,830	2,990	.....	120	10	.....
45	.....	.....	.....	.....	.....	1,460	1,620	1,780	1,930	2,100	2,270	2,430	2,600	2,780	2,960	3,120	.....	122	10	58
46	.....	.....	.....	.....	.....	1,530	1,690	1,860	2,020	2,190	2,360	2,540	2,720	2,900	3,080	3,270	3,420	123	10	.....
47	.....	.....	.....	.....	.....	1,600	1,770	1,940	2,120	2,290	2,460	2,650	2,840	3,020	3,210	3,380	3,560	124	10	34
48	.....	.....	.....	.....	.....	1,670	1,840	2,020	2,210	2,380	2,570	2,760	2,950	3,140	3,340	3,520	3,710	125	10	.....
49	.....	.....	.....	.....	.....	.....	1,920	2,110	2,300	2,480	2,680	2,870	3,070	3,270	3,480	3,660	3,860	126	10	33
50	.....	.....	.....	.....	.....	.....	2,000	2,190	2,390	2,580	2,790	2,990	3,190	3,390	3,610	3,810	4,010	127	10	.....

51							2,080	2,280	2,490	2,690	2,900	3,110	3,320	3,520	3,740	3,950	4,160	128	10	21
52							2,160	2,360	2,580	2,800	3,020	3,230	3,450	3,660	3,880	4,100	4,310	129	10	.....
53							.....	2,450	2,680	2,910	3,130	3,350	3,580	3,800	4,020	4,250	4,470	130	10	8
54							.....	2,550	2,780	3,020	3,250	3,480	3,720	3,940	4,170	4,410	4,640	131	10	.....
55							.....	2,640	2,880	3,130	3,370	3,610	3,860	4,080	4,320	4,570	4,800	132	11	12
56							.....	2,730	2,980	3,250	3,500	3,750	4,000	4,230	4,490	4,740	4,980	133	11	.....
57							.....	.....	3,090	3,370	3,630	3,890	4,150	4,390	4,060	4,920	5,170	134	11	8
58							.....	.....	3,200	3,490	3,750	4,030	4,300	4,560	4,830	5,100	5,370	134	11	.....
59							.....	.....	3,320	3,620	3,890	4,170	4,460	4,720	5,020	5,300	5,580	135	11	9
60							.....	.....	3,440	3,740	4,030	4,320	4,620	4,890	5,200	5,490	5,800	136	11	.....
Total basis	3	39	174	341	333		157		32		4		1		.....	.....	1,084			

Average height of stump is between 1.6 and 3 feet; average length of logs scaled, 14.4 feet.

TABLE 21.—*Incense cedar, seedling growth (height-age), 1912.*

Total height.	Average age of all seedlings below the means.	Mean age.	Average age of all seedlings above the means.
Feet.	*Years.*	*Years.*	*Years.*
0.5	3	5	10
1.0	5	10	17
1.5	8	14	23
2.0	10	19	29
2.5	13	23	34
3.0	15	28	39
3.5	18	32	.....
4.0	20	36	.....
4.5	23	.....	.....

TABLE 22.—*Volume, in board feet, of incense cedar, based on number of 16-foot logs, Plumas, Sequoia, Shasta, and Stanislaus National Forests, California.*

[CURVED.]

Diameter breasthigh.	Number of 16-foot logs.								Average merchantable length.	Diameter inside bark of top.	Basis.
	2	3	4	5	6	7	8	9			
	Volume (board feet).										
Inches.									*Feet.*	*Inches.*	*Trees.*
14	70	130							23	8	
15	80	140							26	8	2
16	90	150							29	8	
17	100	170							32	8	8
18	110	180							34	9	
19	120	200	280						37	9	20
20	130	210	300						40	9	
21	140	230	320						42	9	38
22	160	250	340						45	9	
23	170	270	360	480					48	9	43
24	190	290	390	510					50	9	
25	210	310	420	540					52	9	43
26	230	340	450	570					55	9	
27	250	370	480	610	790				57	9	61
28	270	400	510	650	830				60	9	
29	300	430	550	690	870				62	9	76
30	330	460	590	730	920				64	9	
31	360	490	630	780	970	1,160			67	9	96
32	400	530	670	830	1,020	1,210			70	10	
33		570	720	880	1,070	1,260			72	10	84
34		610	760	940	1,120	1,310			74	10	
35		650	810	990	1,180	1,370			76	10	104
36		700	870	1,050	1,240	1,430			78	10	
37		750	920	1,110	1,310	1,500	1,690		80	10	102
38		800	980	1,170	1,370	1,570	1,780		82	10	
39		860	1,040	1,240	1,450	1,650	1,870		84	10	63
40		920	1,110	1,310	1,520	1,740	1,960		86	10	
41		980	1,180	1,380	1,600	1,830	2,060		88	10	67
42		1,040	1,250	1,460	1,690	1,920	2,170		90	10	
43			1,330	1,540	1,770	2,020	2,270	2,550	91	10	76
44			1,420	1,630	1,860	2,110	2,380	2,670	93	10	
45			1,500	1,730	1,960	2,210	2,490	2,800	94	10	58
46			1,590	1,820	2,050	2,310	2,600	2,930	96	10	
47			1,680	1,920	2,150	2,410	2,720	3,060	97	10	34
48			1,780	2,020	2,240	2,510	2,830	3,200	98	10	
49			1,870	2,110	2,340	2,620	2,960	3,350	100	10	33
50			1,970	2,210	2,440	2,740	3,080	3,500	101	10	
51			2,070	2,300	2,550	2,850	3,220	3,670	102	10	21
52			2,170	2,390	2,650	2,960	3,360	3,840	104	10	
53				2,470	2,750	3,080	3,500	4,020	105	10	8
54				2,550	2,850	3,200	3,650	4,200	106	10	
55				2,630	2,960	3,330	3,810	4,380	108	11	12
56				2,710	3,050	3,450	3,960	4,570	109	11	
57				2,790	3,150	3,580	4,120	4,770	110	11	8
58				2,860	3,250	3,700	4,290	4,970	111	11	
59				2,930	3,340	3,830	4,450	5,180	112	11	9
60				2,990	3,440	3,960	4,610	5,400	114	11	
Total basis	370	1,670	2,650	2,550	1,930	1,090	330	70			1,066

Average height of stump is between 1.6 and 3 feet; average length of logs scaled, 14.4 feet.

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